

REMARKS

Initially, in the Office Action dated November 16, 2005, the Examiner rejects claims 34-52 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,271,110 (Yamaguchi et al.) in view of JP 05-121409 (Akira), U.S. Patent No. 5,643,831 (Ochiai et al.) and JP 05206221 (Michihiko et al.). Claim 53 is allowable.

By the present response, Applicants have submitted new claims 54-60 for consideration by the Examiner and respectfully submit that these claims do not contain any prohibited new matter and are patentable over the cited references. Applicants have amended claim 34 to further clarify the invention. Claims 34-60 remain pending in the present application.

Information Disclosure Statement

Applicants submitted Information Disclosure Statements and Forms PTO-1449 on April 16, 2003 and June 25, 2003. However, Applicant has not received initialed Forms PTO-1449 from the Examiner acknowledging his consideration of the references. Applicant respectfully requests that the Examiner include the initialed Forms PTO-1449 with the next Patent Office communication. Copies of the Forms PTO-1449 filed on April 16, 2003 and June 25, 2003 are attached for the Examiner's convenience.

Allowed claim

Applicants thank the Examiner for indicating that claim 53 is allowable.

35 U.S.C. §103 Rejections

Claims 34-52 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Yamaguchi et al. in view of Akira, Ochiai et al. and Michihiko et al. Applicants have discussed the deficiencies of each of these references in Applicants' previously filed response and re-assert all arguments submitted in that response. Applicants respectfully traverse these rejections and provide the following additional remarks.

Regarding claim 34, Applicants submit that none of the cited references, taken alone or in any proper combination, disclose, suggest or render obvious the limitations in the combination of this claim of, inter alia, producing a semiconductor device that includes forming a plurality of pyramidal bump electrodes of the semiconductor device, where the forming includes forming etched holes by anisotropically etching a base material having a crystal orientation, and filling up the etched holes by plating a metal to form the pyramidal bump electrodes by transferring a shape of the etched holes. As noted previously, Yamaguchi does not disclose or suggest to form the bump of the pyramidal; shape, or to form the bump shape by transferring the anisotropically etched hole.

In the detailed action of the present office action on pages 2-3, the following pair of descriptions reflecting the Examiner's interpretation of Yamaguchi et al. are noted:

- (1) the Examiner asserts that Yamaguchi et al. teaches in Figs. 2a-2b a method of producing a semiconductor device comprising the steps of: forming a plurality of

pyramidal bump electrodes (34) of the semiconductor device, and connecting the pyramidal bump electrodes (34) to pad electrodes (32) of the semiconductor device, and further that the step of forming the plurality of pyramidal bump electrodes (34) including: a step of forming etched holes (14), called cavities, are disclosed in Fig. 2a, col. 6, lines 60-67, and that anisotropically etching base material having a crystal orientation is disclosed in col. 8, lines 37-42; and

(2) the Examiner asserts that a step of filling up the etched holes by plating a metal to form the pyramidal bump electrode by transferring a shape of the etched hole is disclosed in col. 9, lines 17-20, and figure 2B.

According to the description in Yamagami at col. 6, line 60 – col. 7, line 53 with reference to Figs. 2A-2B and the description in col. 8, lines 33-42 with reference to Fig. 4 both related to the aforementioned description (1), “the pyramidal bump electrodes” can be specified as “metal bumps (34)” shown in Fig. 2B connected to electrode pads (32) of the device (30) by transferring the metal balls (26) formed respectively in cavities (14) of a first plane (10) which are formed, e.g., by anisotropic etching of surface (12) of a silicon plate coinciding with the <100> crystallographic plane.

On the other hand, in col. 9, lines 12-30 including the col. 9, lines 17-20 of Yamagami et al. referred in the aforementioned description (2), the client the following underlined descriptions are noted. The description in col. 9, lines 12-30 taught by Yamaguchi et al. are extracted as follows:

Further, according to the present invention, the plate of FIGS. 4 and 5, the plate of FIGS. 6 and 7, and the plate of FIG. 8 can be used

as a die for fabricating a replica, and the first and the second plates 10 and 20 can be molded using this mold.

For example, in FIG. 9A, the numeral 100 designates a plate corresponding to the plate 10 shown in FIGS. 4 to 8. In FIG. 9B, a metal layer of Nickel 102 is formed on the plate 100 by plating or the like. In FIG. 9C, the plate 100 is removed from the metal layer 102, to form a replica die 102A having projects 104 complementary with the cavities of the plate 100. In FIG. 9D, a further metal layer of Nickel 106 is formed on the replica die 102A to a required thickness by plating or the like, again. In FIG. 9E, the replica die 102A is removed from the further metal layer 106, and the further metal layer 106 is subjected to a post-processing shaping to complete a (replica) plate 106A which has the identical shape and pattern to those of the plate 100. This plate 106A can be used as the first and the second plates 10 and 20.
Yamagami et al., col. 9, lines 12-30

According to the preceding description, Yamaguchi et al. teaches "the step of filling up the etched holes by plating a metal," BUT NOT TO form the pyramidal bump electrode as denoted by reference the numeral (34) in Figure 2B.

Yamaguchi et al. teaches to form merely "a replica die 102A" for fabricating the first plate 10 and/or the second plate 20, or "a (replica) plate 106A" used as the first plate 10 and/or the second plate 20. Therefore, a metal (102) plated in the etched holes taught by Yamaguchi et al. should be interpreted to be a TOOL for forming "the metal balls (26) (a precursor of the metal bumps (34))," but never to be the metal bumps (bump electrodes) (34) itself. The Examiner has misunderstood these teaching in Yamagami et al. Applicants respectfully request the Examiner not to confound "a replica die 102A" and "a (replica) plate 106A" with "the pyramidal bump electrodes (34)."

As for the metal bumps (34) or the metal balls (19/26) as precursors thereof, Yamaguchi et al. merely teaches to fill cavities (14/24) by squeegeeing as shown in

Figs. 1A and 1C, and to form the metal balls (19/26) in the cavities (14) by melting metal paste (16) as shown in Figs. 1B and 1E. The Examiner should refer the descriptions in col. 5, line 60 – col. 6, line 59 (explanations of steps shown in Figs. 1A – 1E performed prior to those shown in Figs. 2A – 2C) of Yamaguchi et al. as well as those in col. 6, line 60 – col. 7, line 53 before citing the steps shown in Figs. 2A and 2B for the rejection basis of the pending Claim 34. While Yamaguchi et al. teaches that the metal paste (16) molten in the cavities (24) of the second plate (20) is merged into the metal balls (19) in the cavities (14) of the first plate (10) to form the large-sized metal balls (26) in the cavities (14) of the first plate (10), Yamaguchi et al. does not disclose or suggest to fill the cavities (14/24) with or to form the metal balls (19/26) in the cavities (14/24) by plating the cavities (14/24) with a material as the metal paste (16), etc.

Moreover according to the description in col. 2, line 60 – col. 3, line 6 (Summary of the Invention) taught by Yamaguchi et al., the aforementioned steps shown in Fig. 1B and 1E are performed after the conventional steps explained in col. 1, lines 43-60 esp. as “[t]he solder component of the solder paste in the cavities of the bump-forming plate is heated and molten, and is rounded by surface tension to form solder balls.” Yamaguchi et al. mentions some problems appearing in the conventional step in col. 2, lines 7-23, exemplified as “a Transfer-Defect of the solder ball (i.e. the metal balls) to the semiconductor chip due to small protrusion of the solder ball from a surface of the bump-forming plate” and “a Damage of a surface of

the semiconductor chip due to foreign matter intruding between the bump-forming plate and the semiconductor chip pressed to each other.”

Yamaguchi et al. teaches to solve the former of the problems by merging the molten metal component of the metal paste (16) (as the precursor of the metal ball (19)) in each of the cavities (14) of the first plate (10) with the molten metal component of the metal paste (16) in the corresponding one of the cavities (24) of the second plate (20) to form a single metal ball (26) so as to protrude tops of the metal balls (26) located in the cavities (14) in the first plate (10) out of the cavities (14) sufficiently (hereinafter called **Yamaguchi et al. 1st Intention**), as described in col. 3, lines 16-27 in the Summary of the Invention. Yamaguchi et al. also teaches to solve the latter of the problems by letting the metal balls (26) come into contact with the electrode pads (32) of the device (30) with a comparatively large gap maintained between the plate (10) and the device (16) (hereinafter called **Yamaguchi et al.’s 2nd Intention**), as described in col. 3, lines 41-48 in the Summary of the Invention. It should be noted that Yamaguchi et al. has another Intention to form a replica (102A) having projections (104) on a plate (100) having cavities by plating that is mentioned in col. 3, line 66 – col. 4, line 7 and col. 4, lines 60-63 in the Summary of the Invention separately from the aforementioned Yamaguchi et al.’s 1st and 2nd Intentions.

The limitations in claims of the present invention are completely different from the teachings disclosed in Yamagami et al. As for the step for connecting the pyramidal bump electrodes (5) to pad electrodes (3) of the semiconductor device (2),

as recited in claim 34 of the present application, even though Yamaguchi et al. may teach to flush a surface of the solder paste (16) filled in each cavity (14/24) with the surface of the plate (10/20) as shown in Figs. 1A and 1C, deformation of the metal balls (26) to the pyramidal shape before transferred to the electrode pads (32) of the device (30) is clearly contrary to the Yamaguchi et al. 1st Intention. As each amount of the solder past (16) filled in the respective cavities (14, 24) are regulated in accordance with sizes of the cavities (14, 24), a gross amount of the solder paste (16) for forming the metal ball (26) in each of the cavities (14) is limited. Assuming a part of the solder paste (16) remaining in a space between the metal ball (26) and the plate (10) in Fig. 2A, the protrusion of the metal ball (26) from the surface (12) of the plate (10) will be lower than intended. While the present invention forms a plurality of pyramidal bump electrodes (5) prior to the step for connecting the pyramidal bump electrodes (5) to pad electrodes (3) of the semiconductor device (2) as defined the pending claim 34, Yamaguchi et al. does not disclose or to form the metal ball (26) into the pyramidal shape at the time when the metal ball (26)—the precursor of the metal bumps (34)—is connected to the electrode pads (32) of the device (30) as shown in Fig. 2A.

Moreover, as the definition of a step of filling up the etched holes (36) by plating a metal (6) to form the pyramidal bump electrodes (5) by transferring a shape of the etched holes (36), as recited in claim 34 of the present application, the present invention clearly intends to form the bump electrodes (5) to be connected to the pad electrodes (3) of the semiconductor device (2) in a pyramidal shape. On the other

hand, according to the description in col. 7, lines 7-9 of Yamaguchi et al., while the metal bumps (34) are formed once in a pyramid-like shape as shown in FIG. 2B at least after transferring the metal ball (26) to the electrode pads (32) of the device (30)—separating the metal balls (26) from the plate (34) to be the metal bumps (34)—the metal bumps (34) are deformed to an appropriate shape as shown in FIG. 2C by being heated again. Therefore, Yamaguchi et al. teaches away from the present invention in that it teaches to prevent the metal bumps (34) from being pyramidal rather than to deform it into pyramidal intentionally. While the present invention intends to form the pyramidal bump electrodes (5) after the shape of the etched holes (36) of the base material (32) as defined in the preceding phrase, such the intention of the present invention makes the metal bumps (34) taught by Yamaguchi et al. inappropriate.

Finally, forming the pyramidal bump electrodes (5) by filling up the etched holes (36) by plating the metal (6) is inevitable for the present invention to form the pyramidal bump electrodes (5) after the shape of the etched holes (36) of the base material (32), however, Yamaguchi et al. teaches only to squeegee metal paste (16) coated on a surface (12) of the plate (10/20) for supplying a material of the metal bumps (34) in each cavity (14/24) formed therein. If the material of the metal bumps (34) is supplied in the cavity (14/24) by plating, the material filled in the cavity (14/24) is so stable that it cannot be molten to be rounded by its surface tension. Therefore, the metal ball (26) inevitable in the process taught by Yamaguchi et al. can never be formed of the material filled in the cavity (14/24), and connecting condition of the

metal ball (26) to the electrode pads (32) of the device (30) is never improved. Contrary Yamaguchi et al.'s teaching, in the present invention, due to plating the material of the metal bumps (34) in the cavity (14/24), the stability of the plated film (6) formed in the etched hole (36) provides an advantage to keep the pyramidal shape of the plated film (6) in the present invention even if heat is applied thereto. For example, in the description in page 25, lines 12-18 of Applicants' specification with reference to Fig. 9(h), a number of projection electrodes (5) can keep pyramidal shapes during thermal compression thereof to a number of pad electrodes (3) (see, claims 50-52 pending in the present application). Moreover, in the description in page 14, line 28 – page 15, line 10 of Applicants' specification with reference to Fig. 2, the pyramidal bump electrodes (5) constituting the semiconductor device (1a) and the terminals on the substrate (21) are bonded by thermal compression or soldering without losing pyramidal shapes thereof as shown in Fig. 2.

Moreover, as was noted in Applicants' previously filed response, Akira, Ochiai et al. and Michihiko et al. fail to overcome the deficiencies of Yamagami et al., and do not disclose or suggest the limitations in the claim of the present application, taken alone or in combination.

Regarding claims 35-52 and new claims 54-60, Applicants submit that these claims are dependent on independent claim 34 and, therefore, are patentable at least for the same reasons noted previously regarding this independent claim. Applicants submit that Akira, Ochiai et al. and Michihiko et al. do not overcome the substantial deficiencies noted previously regarding Yamagami et al. For example,

Applicants submit that none of the cited references disclose or suggest where between said step of forming etched holes and said step of filling up the etched holes, further includes a step of forming a primary film of the same material as the metal for said plating of the metal on said base material having a crystal orientation and on a side surface of each of said etched holes, thereby filling up the etched holes by plating the metal by using said primary film, or where after said step of connecting the pyramidal bump electrodes to pad electrodes of the semiconductor device, further includes a step of forming a gold film on a surface of the pyramidal bump electrodes, or where each of the pyramidal bump electrodes keeps its pyramidal shape after the step of connecting pad electrodes of the semiconductor device, or where each tip of the pyramidal bump electrodes is bonded to a terminal formed on a substrate after the step of connecting the pyramidal bump electrodes to pad electrodes of the semiconductor device.

Accordingly, Applicants submit that none of the cited references, taken alone or in any proper combination, disclose suggest or render obvious the limitations in the combination of each of claims 34-60 of the present application. Applicants respectfully request that these rejections be withdraw and that these claims be allowed.

In view of the foregoing amendments and remarks, Applicants submit that claims 34-60 are now in condition for allowance. Accordingly, early allowance of such claims is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, or credit any overpayment of fees, to the deposit account of Mattingly, Stanger, Malur & Brundidge, P.C., Deposit Account No. 50-1417 (referencing attorney docket no. 500.38090X00).

Respectfully submitted,

MATTINGLY, STANGER, MALUR & BRUNDIDGE, P.C.



Frederick D. Bailey
Registration No. 42,282

Attachments:
Forms PTO-1449

FDB/sdb
(703) 684-1120